# SCANNING PROTON MICROPROBE ANALYSIS OF FRAGMENTS OF ALH84001

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The Nuclear Microprobe has continuously evolved over the last twenty years to a level of sophistication matching any analytical instrument available (1). The impetus for this development comes largely from the sensitivity and quantitivity of the technique which can image trace element distributions, measure concentration of parts per million and determine the depth structure of samples. The Oxford Scanning Proton Microprobe Facility uses microPIXE (Proton Induced X-Ray Emission Spectroscopy) combined with Rutherford Backscattering spectroscopy (RBS) coupled to a data acquisition system.

Fragments from the Mars meteorite ALH84001 containing carbonate globules, which could harbour evidence of primitive life (2), were placed into the Microprobe and analysed utilising a beam of MeV protons focused to a diameter of 1 µm. By scanning the beam across the sample elemental maps, line profiles and quantitative point analyses were obtained. The carbon depth distribution within the carbonaceous globule was investigated using resonant proton backscattering, exploiting the C12(p,p)C12 resonance at a proton energy of 1.75MeV (2). This gave a 6 to 10 fold increase in the scattering yield for carbon within a relatively narrow depth range and by increasing the energy of the incident beam the depth of the resonance was pushed deeper into the sample, thus allowing non-destructive, three dimensional analysis of the carbon distribution. At 1.75 MeV carbon at the surface of the globule emits a strong resonance signal (Figure 1). As the beam intensity was increased to 1.85MeV, the carbon resonance peak was reached at a depth of 2 µm into the surface of the globule (Figure 2). At 1.95 µm the carbon resonance depth is 4 µm (Figure 3). Preliminary results utilising this technique have shown that the carbonate globules are between 2 and 4 µm in depth, although further investigations are continuing (Figures1-3).

Elemental mapping of the carbonate globules has produced profiles similar to those reported by Dr. McKay and co-workers. Figure 4, shows the silicon (4a), iron (4b) and sulphur (4c) distribution within a single carbonate globule. These results demonstrated that the silicon content of the base rock disappears at the iron and sulphur rich rim. Iron concentrations were spread evenly through the globule and rim, whilst sulphur was at a high concentration only at the rim. There are areas of high iron content which preliminary data suggests could be linked to high oxygen concentrations. These results are consistent with the report of McKay and co-workers (1).

Preliminary analysis of the point and line spectra from several samples is still ongoing. The quantitative nature of this technique will allow further light to be shed on the exact

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composition of the carbonate globules, and although this work is still in progress final analysis will be completed by mid February.

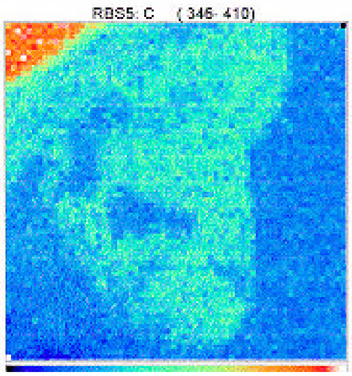


Figure 1. A 1.75 MeV scan showing the carbon distribution at the surface of a carbonate globule.

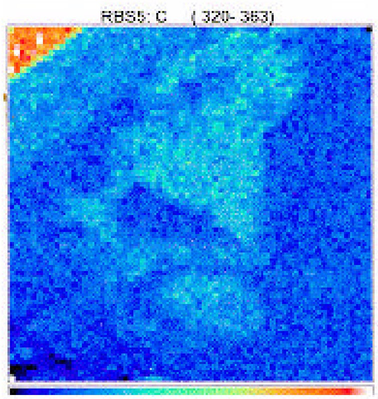


Figure 2. Scan of the carbonate globule at 1.85 MeV, showing the carbon concentration, at a depth of 2µm.

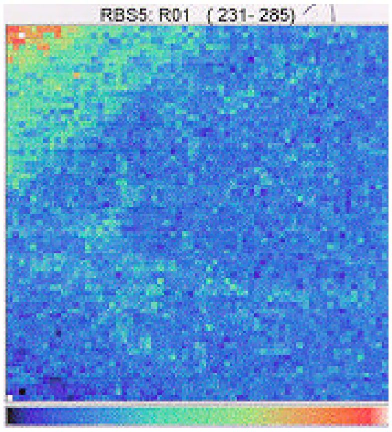


Figure 3. Scan of the carbonate globule at 1.95MeV showing carbon concentration at a depth of 4 µm.

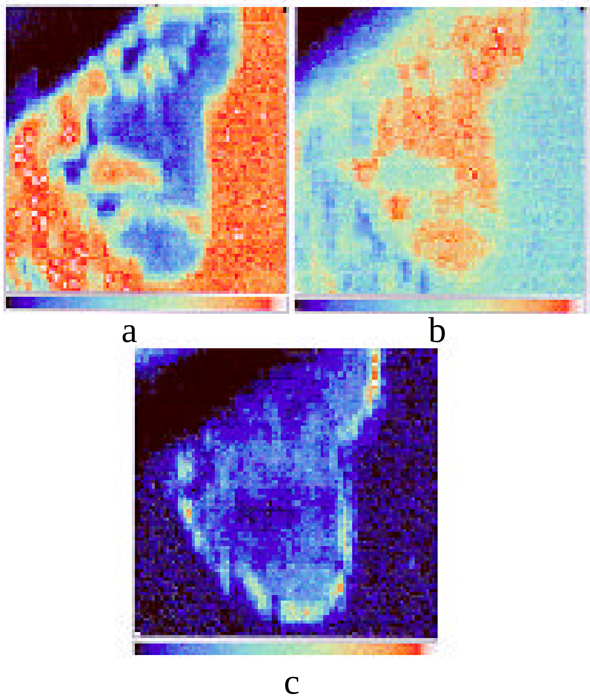


Figure 4. Silicon (a), Iron (b) and Sulphur (c) maps of a carbonate globule.

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2. Grime, G.W. et al., (1991). The Oxford submicron nuclear probe facility. *Nuclear Instruments and Methods in Physics Research*. B54. 52-63.
3. McKay, D. et al (1996). Search for past life on Mars: Possible relics of biogenic activity in martian meteorite ALH84001. *Science* **273**, 924-930.